



Photo: Mirjam Pulleman

Slashing *Canavalia* before planting. Apart from fixing nitrogen, legumes like *Canavalia* or *Mucuna* provide an additional source of quality fodder.

## Soil quality and farm profitability: A win-win situation

**Farmers are more likely to adopt and adapt improved soil management strategies if their efforts lead to an immediate economic benefit. An encouraging policy environment, as well as farmer organisation also stimulates the adoption of conservation practices. In Mexico, farmers are adapting their maize-based cropping systems to conservation agriculture, leading to both higher profits and soil conservation.**

**Mirjam Pulleman, Jon Hellin, Dagoberto Flores Velázquez and Walter López Báez**

Many small scale farmers in Central America and elsewhere grow maize on steep slopes that are prone to erosion and soil degradation. Declining soil productivity, despite high inputs of agro-chemicals, has resulted in lower crop yields. In combination with the increasing costs of maize production, the result is that maize farming is no longer profitable for many smallholder producers. The challenge for these farmers is to adapt their farming systems in order to conserve their soils, while at the same time improving the profitability of their cropping efforts.

### **Towards a living soil**

The principles of what is needed are readily appreciated and understood by researchers, policy-makers, development practitioners – and increasingly by farmers: to restore and sustain the productivity and resilience of soils with regard to their inter-related physical and biological functions and nutrient balances. The narrow concept of “soil” as an inert substrate which can be “improved” by the addition of fertilizers is gradually being replaced in favour of one that sees soil for what it is: a living and self-renewing resource. In the ideal situation, management practices are directed at achieving a self-sustaining system by protecting the soil, feeding it with organic matter, and stimulating the beneficial functions of soil organisms. The aim is to achieve and maintain optimum soil conditions – in physical, chemical, biological and hydrological terms – for root growth, retention and efficient use of water and nutrients, as well as biological control of pests and diseases. This can be achieved through improved cropping practices in the form of “conservation tillage” (or “conservation agriculture”), including minimum soil tillage and retention/mulching of crop residues, protecting the soil against erosion, and encouraging water infiltration and retention. In addition, (leguminous) cover crops can be used to protect the soil. In the medium to long term, the returns of organic matter to the soil and the biological fixation of nitrogen help to restore and maintain soil quality, including its fertility, structure and biological functions.

However, improved crop management strategies are only likely to be adopted and adapted by farmers if their efforts lead to an immediate economic benefit. Furthermore, farmers' decisions need to be put in a wider context. In many rural areas, changes in the global agricultural economy as well as in government policy often result in large-scale migration, rural labour shortages and increased production costs. These changes can undermine farmers' enthusiasm and resources for adopting and adapting practices that maintain and enhance soil quality. Despite these difficulties, this case study illustrates how farmers and researchers of Chiapas, in southeast Mexico, have managed to achieve higher profits as well as natural resource conservation through adapting maize-based cropping systems.

### Biodiversity hotspot

The municipality of Villaflores, in the southwestern part of the state of Chiapas, is characterised by a warm semi-humid climate and by a mountainous landscape. It is considered a biodiversity hotspot. During the 1970s and 1980s, the lowlands became one of the most important maize production regions in Mexico. Cattle production has also increased in recent years. High-input maize production encroached into smallholder slash and burn systems in the narrow valleys and hillsides, where soils are of granitic origin and have a low pH. Productivity is lower here than in the plains. As a result, traditional maize systems were negatively affected and fallow periods shortened. The hillsides became a mosaic of maize fields and early succession forest patches. This led to high erosion rates, soil degradation and a loss of the local biodiversity due to unsustainable practices (including deforestation, overgrazing and traditional practices such as residue burning). These problems are also found in other parts of Mexico and Central America. The result is continued rural poverty and migration, and high costs for society as a whole, due to infrastructure damage and siltation of drinking water resources.

Traditional maize systems in Villaflores are generally of two types. Fields on steep hillsides are unsuitable for mechanisation, and traditional land preparation consists of slashing and burning maize residues ("*roza y quema*"). In contrast, farmers on the plains and terraces use mechanised land preparation in the form of conventional ploughing.

In both systems, maize planting is done manually with a stick after the rains start in May. Manual harvesting of the maize is carried out in December or January. Farmers who have access to land in the plains can sometimes grow a second maize crop ("*chahuite*") or beans as a relay crop in residual moisture. The use of herbicides, pesticides and nitrogen fertilizers is widespread. About 30 percent of the farmers in the region have cattle, ranging from only one cow to at least 30 animals. These farmers rely on crop residues for fodder between January and May. Free grazing is common and farmers who do not have cattle may sell grazing rights to cattle holders. There is thus a trade-off between the need to maintain crop residues on the soil (in order to help maintain soil quality) and the requirement of fodder for animals.

### Management of mixed maize-livestock systems

The combination of traditional land preparation practices with residue grazing has resulted in declining maize productivity, despite increasing use of agro-chemicals. The intensification of maize cropping means that fallow periods are now not long enough to allow the soil to recover. In an attempt to conserve forests and reduce soil erosion, the state government implemented policy measures in the early 1990s to restrict the burning of crop residues, advocating leaving them on the soils. Herbicides and sprayers were also provided to farmers to ease the transition from burning.

Around the same time, a government body called *Fideicomisos Instituidos con Relación a la Agricultura* (FIRA) began to promote reduced and zero tillage as part of a technical package that also included the provision of credit at subsidised interest rates. Although many farmers in the region continue to burn their fields, the majority have abandoned the practice of residue burning. Nonetheless, leaving crop residues on the fields is currently restricted to the less palatable parts of the stalks because livestock rely on such residues during the dry season. Farmers continue to be highly dependent on herbicides, pesticides and chemical fertilizers, the costs of which make up a significant and increasing part of their overall production costs.

### Adapting to conservation agriculture practices

Although the policy changes mentioned above did lead to reduced burning and more crop residues on the hillsides, all farmers with access to land in the plains and on terraces initially continued to plough their soils. Therefore, while organic matter was returned to the soil through maize crop residues, the soil remained bare for a large part of the year, and was thus prone to erosion and water losses through runoff and evaporation. In 1999, FIRA invited farmers in the district of Villaflores to form a group of people interested in conservation agriculture. Tavin Gómez Hernández and six other farmers responded and formed the "*Club de Labranza de Conservación de Villaflores*", electing Mr. Gómez as their president. The first reason farmers chose to reduce or abandon tillage operations was the immediate benefit in the form of reduced costs (tractor time and fuel). However, through experience and information gained from the club's network, farmers became convinced of other major advantages, such as reduced soil erosion, moisture conservation, and restoration of soil fertility and productivity. Although these advantages have not been measured by the farmers, they are clearly visible: when comparing their fields with those practising conventional tillage, club members were able to see clear differences in erosion features, to the extent that the topsoil from upslope conventional plots is being deposited in the fields where surface residues are retained. They also mentioned that maize is better "anchored" in the soil. Since the club started, other farmers became convinced of the benefits of conservation tillage and its membership grew to over 30 members in 2007, while many more farmers in the communities are closely following the developments without actually joining.

The conservation agriculture club plays a crucial role in enabling its members to exchange knowledge and experiences, also sharing ideas with non-member practitioners or interested farmers. It organises field demonstration meetings, and members talk about their experiences at events outside their own region, using the words and concepts close to farmers' realities. The club has not only raised conceptual and practical knowledge on conservation tillage, residue mulching or additional soil and crop improvement measures; it also provides a network for experimentation with new technologies and a focal point for interaction with researchers and government institutions.

### Farm profitability and natural resource conservation

Farmers in the club confirm that the most important incentive for adopting conservation tillage in the plains and terraces has been cost reduction (besides the prohibition of burning). However, there are also other "secondary" incentives. Farmers report moisture conservation and fertility restoration as key benefits, and those working on the most degraded soils report yield increases of up to 100 percent within a few years. Moisture conservation has been so great that fields situated in the lower parts of the watershed can now have a second planting (usually with fodder sorghum or a legume), while this was previously not possible. In collaboration with researchers of local universities

and INIFAP, the national agricultural research institute, many farmers are experimenting with crop intensification and diversification. Legumes like *Mucuna* or *Canavalia* have been tested and grow well, thereby reducing the need to add nitrogen fertilizers, controlling weeds and providing an additional source of improved quality fodder for their own animals (allowing for more crop residues for mulch) or for sale. Although farmers report increased pest problems when leaving residues during the first few years, their experience is that, within three years, the pest problems diminish, most likely as a result of the restoration of the soil's biodiversity leading to improved biological pest control. The farmers that have joined the club since the beginning now mention the reduction of pesticide and herbicide use as one of the major advantages of their system.



Photo: Mirjam Pulleman

**Legume relay crop in maize stalks. Economic benefits and the protection of soil and water go hand in hand.**

Increasing numbers of farmers are convinced of the benefits of leaving crop residues on their land and are trying to find ways to protect this important resource. One important development is the PROCEDE programme, implemented by the national government, that regulates the use of communal land and promotes individual ownership. Farmers who have secured access to land are more inclined to invest in it, for example by fencing their fields in order to protect their residues from invading cattle. Members of the club have also organised themselves into a fire brigade, with the support of the State Secretary of Agriculture. They are now equipped and trained to prevent and extinguish bush fires which come into their land, originating from farmer neighbours who continue to practise burning their fields.

Changes in the farmers' crop management practices are of crucial importance for conservation of soils and for the provision of environmental services such as water quantity and quality, and above- and below-ground biodiversity. All members of the "*Club de Labranza de Conservación de Villaflores*" acknowledge the many benefits of conservation agriculture, and thus encourage other farmers to join them. But they also recognise the magnitude of the challenge, and the need to continuously adapt their systems.

## Future challenges and out-scaling

The Chiapas example demonstrates that immediate economic benefits and the protection of soil and water can go hand in hand, especially when complemented by collective action – in this case a group of farmers organised in a club. The combination of residue management practices that enhance soil and water conservation through crop diversification and intensification options allows for the improvement of crop production and farm profitability. Above- and below-ground biodiversity is stimulated, allowing for higher levels of biological control of weeds, pests and diseases. There are also advantages in the production of alternative fodder sources of higher quality, although further improvements in the efficient use and quality of fodder are still needed. Despite having adopted a better system than the traditional systems, the competition for crop residues (including free grazing) and low quality fodder continues to be a problem, as well as the still relatively high dependency on agro-chemicals.

In particular, the use of herbicides poses a challenge. Farmers have already been using herbicides for some time (especially on sloping land, which farmers never ploughed). Although this has been an advantage to the quick adoption of conservation agriculture methods, herbicide use needs to be reduced in the longer term. Higher levels of residue retention, crop rotations and cover crops will make farmers less dependant on herbicides due to the immediate natural suppression of weeds, and depletion of the seedbank in cases of zero-tillage. Depletion of the seed bank may take several years but depends on the efficiency of weed control by the farmer. Encouragingly, some of the more advanced farmers are already reporting a reduction in herbicide use.

Making the benefits visible and accessible to a wider group of farmers is also a challenge. Many farmers in Villaflores do not yet have access to these new insights or to technical and financial support, and therefore do not benefit from the results seen by the members of the club. Further improvements and out-scaling therefore depend not only on the actions of farmers and researchers alone, but also on the policy environment, the availability and co-ordination of technical and financial support to farmers, and an effective farmers' organisation. One promising development in the case study area is a multi-institutional initiative between INIFAP and other local institutions. This programme, focusing on the integrated sustainable management of the Chiapas watersheds, includes the centralisation and co-ordination of funding, rural planning, research, training and extension, and the organisation of all stakeholders. Payments for ecosystem services to farmers protecting natural resources is one of the strategies being explored. The technologies promoted will build on the experiences described, combined with other resource conserving technologies such as live fencing and agroforestry. All of these initiatives focus on an integrated approach, looking at the entire watershed as a set of interrelated agroecosystems.

**Mirjam Pulleman.** International Maize and Wheat Improvement Center (CIMMYT) and Wageningen University, the Netherlands. Current address: Wageningen University, Department of Soil Quality, P.O. Box 47, 6700 AA Wageningen, the Netherlands. E-mail: mirjam.pulleman@wur.nl

**Jon Hellin and Dagoberto Flores Velázquez.** International Maize and Wheat Improvement Center (CIMMYT), P.O. Box 6-641, CP 06600 Mexico. E-mails: j.hellin@cgiar.org; d.flores@ciar.org

**Walter López Báez,** INIFAP Centro de Chiapas, México. E-mail: waloba10@hotmail.com

## References

- Erenstein, O., 2003. **Smallholder conservation farming in the tropics and sub-tropics: A guide to the development and dissemination of mulching with crop residues and cover crops.** *Agriculture Ecosystems and Environment* 100: 17-37.
- Hellin, J., 2006. **Better land husbandry: From soil conservation to holistic land management.** Science Publishers Inc, Enfield, New Hampshire, U.S.A.